# Quick Guide to Measurements -Filmetrics F54-UV-

- Start-up proceddure
  - 1. Log into FOM and enable the hardware.
  - 2. On the desktop menu, open the "FilMapper" software and wait for the motor initialization to complete.
  - 3. Return to the desktop and open the "UVSource."
  - 4. Enable "Deuterium Lamp On," "Tungsten-Halogen Lamp On," and "Shutter Open."
  - 5. Wait for 5 to 10 minutes for the lamp light to stabilize.
    - a. Wait for 5 minutes for a quick measurement.
    - b. Wait for 10 minutes for an accurate measurement.
- Taking a Baseline
  - From the "Measure" tab, use the "Go To..." command to move the stage to the load position (X = 0, Y = 100), and load the sample onto the stage. Activate "Live Video" if it is not already activated.
  - 2. On the right panel, press the "Baseline..." button, followed by the "Take Sample Reflectance" button.
  - 3. Navigate the sample to the location of interest and hit "Auto Focus."
  - 4. Press "OK" to perform reflectance measurements.
  - 5. Choose the reflectance standard material from the drop-down menu and press the "Take Reflectance Standard" button.
  - 6. Move the stage back to the load position (X = 0, Y = 100), unload your sample, and load the reflectance standard.
  - 7. Bring the stage back to the measurement position (X = 0, Y = 0) and hit "Auto Focus."
  - 8. Press "OK" to perform baseline measurements. Wait for the stage initialization to complete.
- Measurement
  - 1. Unload the reflectance standard and load your sample back onto the stage.
  - 2. Navigate your sample using arrows in the "Live Video" tab or using the "Go To..." command.
  - 3. Select the appropriate recipe from the drop-down menu on the right panel.
  - 4. Press "Edit Recip..." to adjust the initial values of the fitting parameters, such as thicknesses.
  - 5. Press the "Measure" button on the right panel to start the reflectance measurement.
    - a. The measured spectra and fitting results will be displayed in the middle.
    - b. The fitted thicknesses and goodness of fit (GoF) are shown in the lower right corner.
    - c. Save the measurement result from the "File" menu.
    - d. You can access previous results from the "History" tab.
- Shutting down
  - 1. Move the stage to load position (0, 100) and unload your sample.

- Close "FLMapper" software. In the "UVSource" software, uncheck "Deuterium Lamp On", "Tungsten-Halogen Lamp On", and "Shutter Open"
- 3. Log out from FOM.

Yale University Cleanroom		Revision #	3
	Implementation Date	11/20/2023	
Page #	1 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Filmetrics F54-UV

# 1. Purpose

Standard operating procedure for the Filmetrics F54. The Filmetrics F54-UV is a non-contact reflectometer. It uses a large library and pre-set recipes to measure transparent and semi-transparent film thicknesses. This model has a UV light source and a full spectral range of 200 nm to 1100 nm.

# 2. Scope

This SOP is intended for general purpose use of the Filmetrics F54.

### 3. Prerequisites

Users must have cleanroom access.

# 4. Responsibilities

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Yale University Cleanroom		Revision #	3
	Implementation Date	11/20/2023	
Page #	2 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# 5. Tool description

Filmetrics F54 is a tool used for characterizing the thickness and optical properties of thin films based on spectral reflectance (SR). The main differences between SR and ellipsometry are as follows: ellipsometry measures reflectance at a low angle of incidence and also measures two different polarizations (parallel and perpendicular to the plane of incidence). On the other hand, SR measurements utilize light that is reflected at a normal angle to the surface, allowing the polarization effect to be ignored. SR with normal incidence offers advantages such as low cost and high efficiency, along with fast scanning speed, but it lacks sensitivity for films thinner than a few nanometers. For characterizing thinner films, the staff recommends using the Woollam Ellipsometer.

**Spectral reflectance basics:** Suppose we have polarized light traveling inside a material with a refractive index of *n* and an extinction coefficient of *k*. This light can be described in its simplest form at a fixed time as  $A \cos\left(\frac{2\pi nx}{\lambda}\right) exp\left(-\frac{2\pi nx}{\lambda}\right)$ , where *x* is the distance, and  $\lambda$  is the wavelength of the light. The discontinuity in *n* and *k* determines the fraction of the light that is reflected. For the light reflected off of material into the air at a normal angle to the surface, the fraction of reflected light (*R*) can be determined as  $R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2}$ .

In the case of thin films, the light reflected from the top and bottom interfaces can either constructively or destructively interfere with each other, due to the difference in optical path length. Constructive interference occurs when  $2nd = i \lambda$ , and destructive interference occurs when  $2nd = \left(i + \frac{1}{2}\right)\lambda$ , where *d* is the film thickness, and *i* is an integer.

As a result, the reflectance of measured thin films varies periodically with wavelength, with its periodicity and amplitude highly dependent on film thickness and optical constants, as shown in the figure below. By fitting the obtained reflectance spectra, we can estimate the thickness, refractive index, and extinction coefficient of each layer.



Yale Unive		Revision #	3
	Yale University Cleanroom	Implementation Date	11/20/2023
Page #	3 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# 6. Procedure

Before You Start:

 

 Warnings

 DO NOT MOVE THE STAGE BY HANDS DO NOT TOUCH/BEND THE FIBER
 DO NOT TOUCH THE FRONT BUTTONS

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- Refrain from touching the fiber optic cable to avoid damaging the system.
- This system uses an automated stage. Do not move it by hand and be sure all hands and objects are clear when starting the software and scanning. Never leave objects on the system surface.
- Please refrain from manually pressing power buttons or lamp switches. The tool is typically meant to be left on, and the lamps should be controlled through the software.

Start Up Procedure:

1. Log into FOM to enable the hardware.

Log into FOM	Turn on the device
Select Login Option Login with Yale NeIID Login with FOM username and password	Current reservation       ×         Comment by previous user:       OK         OK       Resource: Filmetrics F54-UV         Relay Status:       OFF         Turn on       Click!         Reservation purpose:       For user support         Reservation:       11/3 9:15 - 11/3 10:15         Usage Comment:       ///For user support         Logon       Cancel without charge         Record ID 218996 at 2023-11-03 09:05:42       Close

2. Open the **FILMapper** software available on the desktop and wait for the software to initialize.

Yale University Cle		Revision #	3
	Yale University Cleanroom	Implementation Date	11/20/2023
Page #	4 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$





Wait for the motor initialization to be

3. Return to the desktop and open the UVSource light source control. Select Tungsten-Halogen Lamp On, Deuterium Lamp On, and Shutter Open.

Open UVSource	Turn on the lamps and shutter	
	Status Control Signals	
FUMappar	Deuterium Lamp Warning: False On: True Fault: False	
UVSource Click!	Lamp On Time (hrs): [318:30] Reset  Tungsten-Halogen Lamp On: Time Burnout: Failee Lamp On Time (hrs): [754 65] Reset	
Filmetrics Saved Data	Shutter Open: True	
	OverTemperature: Faile TUTT these three On Fan Falure: Faile Front Panel Disable Front Panel Disabled: Faile ResetMicro	

4. Check if all three lights on the UV source front should be lit. Wait at least five minutes for the lamp sources to stabilize. Wait fifteen minutes for best results.

Yale University Cleanroom		Revision #	3
	Implementation Date	11/20/2023	
Page #	5 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Check if lamp lights are all lit

### Wait for the lamps to be warmed up

- For basic characterization: Wait for ≥ 5 min.
- For more precise measurements: Wait for additional 10 min. (15 min. total).
- Taking a Baseline: The system baseline measures known values to calculate measurement offsets. You will first take a baseline reflectance of your sample and then the Si standard wafer.
  - 1. From the **Measure** tab, use the "**Go To...**" command to bring the system chuck out towards you (X=0, Y=100).



2. Load your sample on the center, and then activate the "Live video" on the left side of the Measure tab.

Yale University Cleanroom		Revision #	3
	Implementation Date	11/20/2023	
Page #	6 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Load the sample on the center







3. Press the **"Baseline...**" button followed by the **"Take Sample Reflectance**" button.

HIT Baseline	Hit Take Sample Reflectance
History         Sample Info         Sample Info         Sample Info         Operator ID:         Objective:         Info         Objective:         Info         Info	Take Reflectance Standard Procedure  Step 1 of 2: Take Sample Reflectance  Place sample to be measured on the stage Click Take Sample Reflectance  Click!  Take Sample Reflectance  Override  Status: Not yet completed
Measurement # 860	Recover Last Baseline < Prev Next> Cancel

4. If your sample is inhomogeneous, navigate to the location of interest by using arrows in the "Measurement Spot Focus" dialogue or by typing the coordinates and pressing "Move."

Yale University Cleanroom		Revision #	3
	Implementation Date	11/20/2023	
Page #	7 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$



- >>: moving continuously
- 5. Adjust the focus on your sample to maximize intensity either by using the "Measurement Spot Focus" dialogue or by using "Auto Focus" (recommended) when appropriate.



Live Video at max intensity



6. Press **OK** to measure reflectance.

37.1		Revision #
Yale University Clear	Yale University Cleanroom	Implementation Date
Page #	8 of 16	Last Reviewed/Update Date
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval

# Hit "OK" to start baseline measurement

Measurement Spot Focus						
Adjust Focus until the signal is maximized. Click OK to continue Baseline, click Cancel to abort.						
	30	X (mm)				
	0	Y (mm)				
«	> >	Rotation				
* *	~ 1	Translation				
*	~ :	📚 3.376 Z (n	nm)			
Mo	ve	Current				
Auto F	ocus	Autoscale Gain	I.			
Click!	OK	Cancel				

# Wait until reflectance measurement to be done

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	Step 1 of 2: Take Sample Reflectance
	•Place sample to be measured on the stage •Click Take Sample Reflectance
Here	Take Sample Reflectance Override
	Status:
ecover Last	- Prov. Novt > Con

7. Choose your reflectance standard materials from the drop-down menu. Press the "Take Reflectance Standard" button to initiate the reflectance measurement of the standard sample.



8. Move the stage to the loading position (X = 0, Y = 100). Unload your sample and load the reflectance standard. If your reflectance standard is silicon (Si), you will require a silicon wafer, either your own or one available on the tool.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	9 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Navigate the stage to sample loading position

		Measurer	ment Sp	ot Focus	5		
ke Reflectance Stan	dard Procedure	Adjust F	ocus u	ntil the	signal	is maximize	d.
	Step 2 of 2: Tak	Click Of		tinue B	aselin	e, click Can	cei to abor
It m	•Center the Focus/Ref •Click Take Reflectan		-1	100		Y (mm)	' = 10
	(5 minute lamp warm-u	<	<	>	>>>	Rotation	
	Pofloctanco S	*	~	~	*	Translatio	on
	Tak	*	*	~	*	3.372	Z (mm)
	(2	ר,	Мо	ve		Curre	nt
	Status: Not y		ALIMOV	es to th	e positi	on entered al	h
	< Prev			OK		Cancel	

# Unload your sample / load reflectance standard



Si reflectance standard

9. Navigate the sample to the measurement position. Focus on the reflectance standard either by using the measurement spot focus dialogue or the "Auto Focus". <u>Please note that if you used "Auto Focus" for sample reflectance, also use "Auto Focus" for the reflectance standard. Press "OK" to generate baseline values.</u>



10. Please wait until the baseline measurement is complete. Once the baseline measurement is finished, the stage motion initialization process will begin. Please do not interrupt the initialization process, as it will take less than a minute.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	10 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Wait for baseline measurement

# Wait for stage initialization

ake Reflectance Star	ndard Procedure	Take Reflectance Standard Procedure
[	Step 2 of 2: Take Reflectance Standard	Step 2 of 2: Take Reflectance Standard
	Center the Focus/Reference Wafer on stage (flat toward front)     Click Take Reflectance Standard     (5 minute lamp warm-up recommended for best results.)*	Contact the Encure (Reference Water on stand (flat toward frogt)     Stage Position Homing X
	Reflectance Standard: Si	Finding mirror vertical edges
	Take Reflectance Standard	Manual Stage Homing
	Status: *Warm-up Time	Jrm-up Time
	< Prev Finish Cancel	< Prev Finish Cancel

Measurement: Basic single-spot measurements are taken using the **Measure** tab. Contact a staff member for instructions on how to use Wafer Mapping.

1. Unload reflectance standard and load again your sample.





2. Navigate your sample using the on-screen arrows in the "Live Video tab" or using "Go To..." dialogue. The dot in the center is the system's measurement location.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	11 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$



3. Select the measurement recipe in the drop-down menu.

Wait for baseline measurement	Select the recipe
Objective: 10X  Measure Go To Baseline Analyze Click! Si02 on Si - Video Training+Mappi Edit Recipe	Recipe Selection         Pacopes         A203 on Quatz         A203 on SO2 on Si         A203 on SO2 on Si         AN on NoN on Sapphire         M Non Sapphire         DefaultRecipe         G GaN on Al203         G GaN on SO2 on Si         H M Mon Sapphire         DefaultRecipe         G GaN on Al203         G GaN on Si2 on Si         H M Ressurement         InP         LINBO on Si2 on Si         B LuNBO on Si2 on Si         D Loga/aptistion Reflectance         D LingA Azolasion Si2 on Si         P Muk Action Sapphire         P matier on Si22         No nu LiNbo on Si2 on Si         P DMS on Xi203         P PMMA A2X03 Yami

4. Press **"Edit Recipe..."** to adjust the recipe's starting parameters/thickness. If you add or remove a layer or modify the material's parameters, please save the recipe with a different name. DO NOT overwrite the previous recipe. Contact a staff member for more information on recipe editing.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	12 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Hit "Edit Recipe..." to adjust the recipe's starting parameters/thickness.



5. Once the system is baselined, your sample is in position, and your recipe is set, press the "**Measure**" button to scan your sample.



6. The film thickness and goodness of fit will appear in the bottom right of the tab in "Measurement Results."

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	13 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Check reflectance results and fitting parameters

Save reflectance results in "File" menu or "History" tab



7. If a measurement needs to be saved do so using the File menu command "Saved Measured Spectrum," "Save Screen to File," and "Saved Measured n and k" when applicable. A variety of file formats are available for easy export. You can also access the previously measured spectra in the "History" tab.



Hit this to bring the selected measurement to the "Measure" tab

# Shutting Down:

1. Bring the stage to the load/unload position at (0,100) using "**Go To...**" dialogue, remove all samples from the stage.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	14 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Navigate to sample loading position







ResetMicro

2. Press the X button in the top right of the screen. Turn off the halogen and deuterium lamps, and close the shutter, using the **UVSource** software. Visually confirm the lights on the light source are off.



Front Panel Disabled: False

3. Log out of the system in **FOM**.

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	15 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

# Log out of the system in FOM

Current reservation	×
Comment by previous user: OK Resource: Filmetrics F54-UV Relay Status: ON Reservation purpose: For user support Reservation: 11/3 9:15 - 11/3 10:15 Usage Comment:	
//For user support	< >
Logon Cancel without charge Cancel with charge	
Record ID 218996 at 2023-11-03 09:05:42 Close	

# 7. Advanced Tips

**Transparent Substrates:** When measuring films on transparent substrates, reflectance from the backside of the substrate may occur. Selecting Compensate for: Unmodeled backside reflections allows the software to shift the intensity of the calculated reflectance curve to account for the additional light. This feature should not be used when measuring very thin films (< 100 nm).

**Tilted Sample/Lost Light:** Samples with non-coplanar surfaces scatter some of the light away from the collection optics. This option automatically compensates for the light lost due to nonplanarity.

**Lock Identical Layers:** Samples comprised of repeating layers can be more accurately measured by activating this option. By activating these options, all properties of any layers that initially have the same material or thickness are locked together.

**Exact Spectrum Matching:** The Exact Spectrum Matching is one of three analysis methods available in FILMapper. This solver can be used to measure thickness, thickness nonuniformity, and roughness of single and multilayer films, and can additionally solve for index.

**Enable FFT (Thickness Only):** The FFT (thickness only) solver is one of three analysis methods available in the FILMapper software. This solver is best suited for films greater than 250 nm thick, as well as multi-layered films. It is also an effective option when the index of refraction of the film isn't well known. While this feature is selected there will be fewer options under the Analysis Options tab. You cannot solve for index, roughness, or nonuniformity with the FFT (thickness only) solver enabled.

**Robust Thickness:** The Robust (adaptive; thickness only) solver is one of three analysis methods available within FILMapper. It is best suited for measuring the thickness of single-layer films greater than 150 nm thick. This method can oftentimes successfully measure films when the data is affected by non-ideal properties, such as thickness nonuniformity, grading, and birefringence. Much like the FFT solver, enabling Robust will limit the options

Yale	Yale University Cleanroom	Revision #	3
		Implementation Date	11/20/2023
Page #	16 of 16	Last Reviewed/Update Date	11/20/2023
SOP Owner	Lauren McCabe/Yeongjae Shin	Approval	$\checkmark$

available in the Analysis options tab. You also cannot solve for roughness, nonuniformity or index with the Robust solver enabled.